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THE LAW OF DIMINISHING RETURNS[1]

By Dr. JOEL STEBBINS

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IN the Encyclopaedia Britannica under the heading, "Law of Diminishing Returns," we find that this law was first stated in relation to agriculture:

> An increase in the capital and labor applied to the cultivation of land causes in general a less than proportionate increase in the amount of produce raised unless it happens to coincide with an improvement in the arts of agriculture.

In economics, then, the law of diminishing returns is merely a precise statement of what is ordinarily recognized in the affairs of the working world. Everybody knows that, after a certain point, work in given conditions yields a diminishing return unless a better method is invented applicable to those conditions.

We in this society naturally include astronomy in the affairs of the working world, and it may be instructive to trace some of the applications of the law of diminishing returns in our own field. To begin with, this law took hold of the increasing size of refracting telescopes and brought further development to a close with the completion of the 40-inch refractor some fifty years ago. True, it was the rediscovery of the possibilities of the reflecting telescope that turned the construction of new instruments into the other form. But even if there had been no reflectors it was obvious from geometrical and optical principles, not to mention atmospheric limitations, that each increase in size of the objective of a refractor was accompanied by less than a proportionate increase of power.

The same law is now holding for reflectors even if the 200-inch, as we hope, should turn out to be a complete success. I understand that at Mount Wilson the 100-inch reflector cost about four times as much as the 60-inch, while the 200-inch will cost ten times as much as the 100-inch. No one thinks for a moment that the resulting gain in power will be proportional to the outlay. These facts are elementary to astronomers but to the laymen we might quote the simple

[1] Address of the retiring president of the American Astronomical Society, November 6, 1943.

rule that the cost of a good telescope can be roughly proportional to the cube of its linear aperture.

Despite these facts how many of us, if we were offered the money for a well-endowed 100-inch telescope, would have the moral courage to say that we would prefer to build an 80-inch and use the balance of the funds for additional improved attachments and for even better operation? The difference between 80 and 100 inches is practically not as important as the difference between poor and good seeing. Ask any observer on Mount Wilson which he would rather have, a fine night with the 60-inch or a poor, or even a fair, night with the 100-inch. The answer does not mean that the larger instrument has not been a success. Certain things have been done with it for the first time which had not been done with smaller reflectors. While experience has shown that some discoveries could have been made with smaller telescopes, the fact remains that they were not made. Near the limit of observational detection the extra power of the largest telescope available is an advantage.

My own experience with the law of diminishing returns began in another fashion years ago when I was a night assistant at the Crossley reflector of the Lick Observatory. My chief at the time was Charles D. Perrine who, to say the least, was an indefatigable observer. Those were the days, or rather the nights, of long exposures, perhaps only two plates per night, and toward dawn it used to seem to me that the last fifteen minutes of a four-hour exposure were time purely wasted. Though I did not venture to say so, I was sure that on the resulting plate no one could tell the difference between an exposure of four hours and one 15 minutes shorter, so that we might as well close up and go to bed. The answer to this argument is obvious to any one, but I could maintain that by shaving off a little time from each of several exposures we might get in an additional plate at the end.

However, Mr. Perrine kept on in his industrious way and proposed to expose for 10 hours over two nights on the region of Nova Persei. I believe that the time was cut to about seven hours by an oncoming storm, but on the resulting plate Perrine found the rapid expansion of the nebulosity about the nova, the first such motion to be discovered and one which holds the record for speed which will not be surpassed, inasmuch as it presumably represents the velocity of light.

Although this episode might justly be considered to indicate the failure of the law of diminishing returns, in another sense the instinct of a sleepy assistant was sound. Perhaps he had a feeling for the failure of the reciprocity law in photography, governing the relation between intensity and exposure time. To secure constant density of the photographic image, the time must be increased in greater proportion as the intensity of the incident light is decreased.

$$It^p = \text{constant}$$

In this equation giving the relation between intensity I and exposure t, where p is less than unity, we have the exact formulation of one law of diminishing returns.

But quite apart from the photographic action for threshold images the limit for faint stars that can be photographed with any telescope is set by the brightness of the sky background. The exposures of seven or eight hours with the Crossley reflector of focal ratio f/6, made forty years ago, are not practical now with faster modern plates. It takes an unusually dark sky to make it worth while to expose more than two hours with a reflector of focal ratio f/5. What we want is some region along the spectrum to act as a sort of window and allow us to photograph or see through to the stars and nebulae with a relatively reduced sky brightness. Such a window has been found and utilized by W. Baade with the 100-inch reflector. With red-sensitive plates and a filter transmitting the region 6,000 Å–6,700 Å he has crashed through both the atmosphere and the interstellar dust clouds to record stars that can not be reached with ordinary blue-sensitive plates. In fact, the prospect is that the beautiful and valuable photographs of the Ross "Atlas of the Milky Way" will have to be made all over again with a Schmidt telescope and red-sensitive plates.

Whereas, even without the failure of the reciprocity law, the fogging by the sky light would place a practical limit to the time of exposure of direct photographs, the same limitation does not apply in spectrum plates of moderately faint stars, where there is still plenty of contrast between a star image and the sky background. It has been said that until recently the best method of getting the red or infrared spectrum of a star was simply "to wait." By postponing the work for a year or so, one could count on the development of a new plate which would be so much more sensitive in the long wave-lengths that it seemed scarcely worth while to make the effort of long exposures with faster plates in prospect. Perhaps here is an instance of the law of increasing returns. Take things easy and some one else will make your work still easier. Seriously, he is wise indeed who can strike the proper balance between using the means at hand for a given problem and waiting for or developing new means for doing the same thing better or more easily.

At one time, when our science was being divided into the old astronomy and the new astrophysics, there were more than one of the old guard who used to say that in the astronomy of precision, as they called it, one could count upon an hour's results from an hour's work, whereas in astrophysics a large part of the experimenter's time was likely to be wasted. But

even in well-established routine researches the law of diminishing returns came into force. Consider, for example, the weights assigned to star positions from different catalogues of meridian observations. In the Boss "General Catalogue" the probable error of a position was considered to consist of two parts, the first being independent of the number of observations and the second diminishing with the number of observations according to the formula,

$$r^2 = r^2_0 + r^2_1/n$$

A glance at the tables in the "General Catalogue" shows that the weights almost never increase in proportion to the number of observations, and after a certain limit no greater weight is given no matter what the number of observations. We all probably treat our own measures of any kind in the same fashion. We repeat settings only to the point where additional ones are of little value because of the presence of errors which are not eliminated. This principle is applicable throughout physical science.

But it is not so much the fact that repeating the same work over and over leads to the law of diminishing returns as that some new method will revolutionize a whole field. When the late Dr. Frank Schlesinger took up the determination of parallaxes by photography with the long-focus Yerkes refractor, all previous parallaxes with the heliometer or meridian circle were soon superseded. Yet only last spring during my final visit with Dr. Schlesinger he remarked that the observational program for trigonometric parallaxes is about worked out. In forty years the law of diminishing returns has taken hold again.

It was Simon Newcomb, the first president of the American Astronomical Society, who said: "To be revised, pulled to pieces, or superseded as science advances is the common fate of most astronomical work, even the best. It does not follow it has been done in vain; if good it forms a foundation on which others will build. But not every investigator can look on with philosophic calm when he sees his work thus treated." Another president, Edward C. Pickering, while presiding over a session, once remarked, in a discussion of some of the new methods of stellar photometry, that he had made a good many visual photometric observations himself (the number was more than a million) but he expected them all to be superseded. In his later years Pickering decided that the magnitudes of the fainter stars could best be determined by photography and he diligently devised and carried on photographic programs. However, the visual work of Pickering still stands and will stand for a long time.

My own field of photometry may be considered to come under the law of diminishing returns, since the light from a star diminishes with the square of the distance and in proportion to the absorption in space. Over the years I have read a number of papers before the society, probably of diminishing value, and the present may be an appropriate occasion to summarize some of them. I believe that at one time I reported that the sensitivity of the selenium photometer had been increased 100-fold; at another time, two magnitudes more. Then the photoelectric cell was reported as being two magnitudes better than the selenium cell. In a few years more perhaps another 1.5 magnitudes was picked up with the photocell, and then the application of the thermionic amplifier was developed by A. E. Whitford, giving a four-fold increase or still another 1.5 magnitudes. Adding these reported improvements together we have $5+2+2+1.5+1.5=12$ magnitudes, or a factor of 63,000.

Strangely enough, something has been left out. When F. C. Brown and I first mounted a selenium cell at the focus of a 12-inch refractor and pointed the telescope at Jupiter there was no detectable response whatever. Since then the faintest object which Whitford and I have measured with a photocell is a star of magnitude 16.1 with the 100-inch reflector. As the probable error of measurement was about 10 per cent., the limit of detection may fairly be called magnitude 18. From Jupiter at magnitude -2 to a star at $+18$ the change is 20 magnitudes. This advance is perhaps not so much a measure of the excellence of the latest developments as of the crudeness of the first attempts. Moreover, we must allow say 5 magnitudes for the difference between a 12-inch and a 100-inch telescope, leaving 15 magnitudes or a million-fold improvement in the apparatus itself. The limit of magnitude 16 was reached six or seven years ago, and the law of diminishing returns is working now. We can predict with confidence that the next 20 magnitudes will be harder to get.

When my friend and colleague Jakob Kunz passed on some five years ago he was still optimistic about getting a more sensitive photoelectric surface of potassium hydride. In fact he had actually produced cells which gave ten times the response of some of the best cells on hand, but unfortunately they were not stable and the surfaces deteriorated in a few days or weeks. There are other blue-sensitive cells now available which give a response in micro-amperes per lumen considerably better than the best Kunz cells, but the commercial cells are usually not constructed with the extreme insulation needed for detecting small currents. It is the old story of what you want versus what you don't want, or the ratio of signal to noise, as they say in radio. Suffice it to say that there already exists the possibility of a photoelectric surface which, if deposited in the right way in the right cell or tube, will give greater effective sensitivity than anything so

far available, but whether the improvement will be as much as 10-fold is more than I can tell.

But how about the relative precision of measurement as the effective sensitivity of a stellar photometer was being increased? The answer is definite; while six decimal places in sensitivity were being picked up, a single decimal place in increased precision was scarcely achieved. I used to have a goal of a thousandth of a magnitude for the probable error of the magnitude of a star, but I have never reached it. However, that precision has been reached by Gerald Kron at the Lick Observatory. He has established the light-curve of at least one variable star with normal magnitudes having a probable error of ± 0.001 magnitude (*Lick Obs. Bulletin,* No. 499, 1939). As Kron has remarked to me, the limit of precision for bright stars observed with a small telescope, say up to 36 inches, is fixed not by the photocell, not by the amplifier, not even by the astronomer; it is fixed by the quality of the seeing. It took me a long time to learn that fact, but it is true, and it has been demonstrated by Whitford at Madison and Mount Wilson. Using a photocell, a short-period amplifier and an oscillograph to reveal the rapid fluctuations of a star at the focus of a telescope, he has recorded the difference between poor and good seeing. In poor seeing a star may vary four- or five-fold in intensity within 1/20 or 1/30 second, while in good seeing the maximum deviation may be not more than 10 or 15 per cent. from the mean in the course of a whole second. With a galvanometer and circuit requiring 10 or 15 seconds to give a full deflection these irregularities are smoothed out to a great extent, but under ordinary conditions with a 15-inch telescope jumps of 0.5 to 1.0 per cent. at the end of a long-period deflection are quite common. With the 60-inch or 100-inch telescope the galvanometer is much steadier at the top of a deflection, and 0.1 per cent. or 0.001 magnitude does not look so far out of reach.

An example of the futility of taking more than a reasonable number of measures of the same thing is furnished by the light-curve of the variable, Delta Cephei, which I determined visually some 35 years ago. About 7,000 individual settings were made on 72 nights, and I decided that nothing would be gained by further observations. This visual light-curve may be compared with recent curves determined with the 60-inch reflector at Mount Wilson, using a photocell and filters which isolate six different regions of the spectrum. In about a third of the observing time which had been devoted to the visual work, it was possible to get light-curves in the six colors, each one being superior to the visual light-curve. The results furnish material for the theoretical study of this type of light variation. The new curves are uniformly smooth, showing no secondary fluctuations or humps. The amplitude of variation at 3,530 Å is about 3½ times the amplitude at 10,300 Å. There is a retardation of phase for the longer wave-lengths in the sense that the maxima and minima of light are later in the infrared than in the ultraviolet. The colors of the star at different phases are quite close to the colors of normal giants, ranging from F4 at maximum to G2 at minimum in good accordance with the changes in the spectrum.

During the past ten years with my colleagues, Huffer and Whitford, I have spent a good deal of effort in determining color indices of stars with a photocell. These results have been criticized, principally by ourselves, because of the short base line or leverage furnished by the cell and filters used, the difference between the two spectral regions being little more than half the corresponding difference in the international system. The new six-color measures give so much more information about the radiation from a star that the old two-color measures are already out of date. Moreover, the extreme base line from 3,530 Å to 10,300 Å gives a scale some 7.5 times our former scale of color index. But here again, even while we are enjoying the power of the new method, the law of diminishing returns seems to have set in. The measures in the ultraviolet have been very useful in the application to extragalactic nebulae and in the determination of the law of interstellar absorption from reddened B stars, but experience has shown that for most stars a less extended base line will serve just as well. When a star's radiation is nearly a linear function of $1/\lambda$ there is no advantage in a very long base line, because of the dispersion in the characteristics of stars of the same spectral class. Moreover, the ultraviolet measures are especially affected by hydrogen absorption in some stars and by variations in our own atmosphere. Therefore, it may be best to reduce the number of colors from say six to four, omitting the ultraviolet and the blue or green.

To utilize an intermediate base line for color index we have recently tried out a cell and two filters with effective wave-lengths of 4,200 Å and 7,900 Å for a source at 10,000°K, giving a scale about 4 times the old photoelectric scale. This combination is good for the detection of small amounts of space reddening in early-type stars and is generally useful in measuring color indices of all stars. The red filter, however, transmits the radiation from what we believe to be one or more auroral lines in the neighborhood of 10,000 Å, certainly of wave-length longer than 8,500 Å. When this cell is exposed to the sky alone through an infrared filter, the relative intensity near 10,000 Å, compared with a solar type star, is 10 times the intensity of any other part of the spectrum. A further study

of this line or lines awaits the spectroscopists, but we know that the radiation is atmospheric from its irregular behavior throughout the night.

A communication from Dr. V. M. Slipher confirms the presence of this strong infrared radiation in the night sky, but he has not yet determined the wave-length. A rough comparison of the observed relative galvanometer deflections along the spectrum of the sky with the deflection from a star of spectrum dF7 is as follows:

Wave-length		3,530	4,220	4,880	5,700	7,190	10,300
Deflections,	dF7	8	8	10	8	8	8 mm
"	Sky	8	5	5	8	13	112 mm

Also, compared with other regions of the spectrum, the infrared has varied from summer to summer somewhat as follows:

1941	60
1942	80
1943	112

One is naturally suspicious of a connection with the sunspot cycle.

Even with this handicap of the sky radiation the new color system which we call C_3 can be used on the brighter nebulae, and we have started of course with M31, the Andromeda nebula, just to see what would happen. It turns out that there is a difference in the color of the two sides of the nebula which, if interpreted as the effect of space reddening like that in the galaxy, gives at once the ratio of total to selective absorption. The new results may be summarized briefly. Let A_{pg} be the total photographic absorption, E_1 the old, E_3 the new, and E the international color excess, respectively. Then the different relations and the basis for each are as follows:

(1)	$A_{pg}/E_3 = 2.01 \pm 0.10$	(p.e.)	Andromeda nebula
(2)	$E_3/E_1 = 3.86 \pm 0.13$		Reddened B stars
(3)	$A_{pg}/E_1 = 7.8 \pm 0.5$		(1) × (2)
(4)	$E/E_1 = 1.90 \pm 0.12$		Seares, A stars
(5)	$A_{pg}/E = 4.1 \pm 0.4$		(3)/(4)

The weak step in the sequence is presumably in (4), the ratio of the international to the photoelectric scale. The result by Seares is from 52 A-type stars near the north pole, and is actually the ratio of the colors C/C_1 rather than the color excesses E/E_1. The latter ratio is probably higher than the former. Unfortunately, nature has given us few B stars in the vicinity of the pole, and the interstellar absorption there is too small to give a reliable comparison of the two scales of space reddening.

It should be emphasized again that these results depend upon the assumption that selective absorption in the Andromeda nebula is the same as in the galaxy, also that the apparent surface brightness of the nebula for the regions measured would be symmetrical about the nucleus if there were no such absorption. However, the ratios in equations (3) and (5) look reasonable and the value $A_{pg}/E = 4.1$ will probably be welcomed by those who have claimed that a higher value of this ratio does not agree with the conclusions from star counts and other evidence in the galaxy.

Incidentally, if we assume that the absorption is caused by a thin layer near the median plane, these photoelectric results are in agreement with the view that the main dark lane of the nebula is on the near side, and therefore that the direction of rotation is such that the arms of the spiral are trailing.

I have included these examples from photometry not so much to illustrate the application of the law of diminishing returns as to show some efforts to combat that law. Perhaps the difference between the law of diminishing returns and the law of increasing returns is merely the difference between looking backward and looking forward. It has been well said that just as soon as a problem becomes easy it ceases to be research; if you are doing real research you are likely to be in difficulties most of the time. We have it from Bobby Jones that there is no easy shot in golf. If it is easy to get your ball on the green you should be aiming at the pin.

If I were to draw any moral from these remarks, it would be to remember that it takes only a slight improvement over what has gone before to open up entirely new opportunities. If the law of diminishing returns seems to prevent us from doing something better, we can always try to do something different.

OBITUARY

HERMAN LEROY FAIRCHILD
1850–1943

ON the 29th of November Emeritus Professor Fairchild, of the University of Rochester, long an outstanding figure in American geology, passed on at the age of 93 years. Professor Fairchild was the last of a famous geological group belonging to an earlier generation, boasting many names that will be remembered as long as geologic science, as we know it, lasts.

For more than 70 years he devoted his life to education in science—teaching, lecturing, organizing, advising, investigating and writing—all with marked success. His more than 200 published writings covered a wide field and shed luster on the institution that he served with great devotion for more than a half century. He contributed much to organized science. No one in his time was more continuously engaged or more successful in developing scientific organizations to larger usefulness. He was a constructive person. Whatever he touched seemed to be improved. Every

organization grew. And it was at least in part his enthusiasm and confident service that made them grow.

In his early years, fresh from college, he became secretary of the New York Academy of Sciences. For sixteen years he was secretary of the Geological Society of America. For very many years longer he maintained close administrative and advisory relations with the American Association for the Advancement of Science, becoming a member of its executive and policy committee. He was the guiding spirit of the Rochester Academy through more than a life-time. His intimate knowledge of the steps that led to their founding and development in each case made him the natural authority on their history, and his volumes are everywhere consulted on these matters.

To Harmon C. and Mary A. Bissell Fairchild the boy named Herman Le Roy was born on April 29, 1850, at Montrose in northeastern Pennsylvania, where his boyhood and youth were spent on a farm, and where also, he secured from country schools the foundations of an education that gave bent to a long lifetime of surprisingly productive effort and wide influence. It should be noted, also, that he began at this time to show interest in geology by making a collection of fossils of his own. Later he was to develop special interest and reputation in glacial history and the interpretation of surface features of the lands affected by those events.

At the age of sixteen he began teaching in a country district school, boarding around, where he developed a liking for public speaking and a facility of expression that was to make him a powerful figure in later years. After three winters of this elementary work he was employed an additional year as clerk in a local railway freight office, but this seems to have been strictly a side issue, probably to raise funds for college. For at the age of twenty, he entered Cornell University, where he completed a regular college course and earned a B.S. degree in 1874.

Not much is known of his activities there. But it appears from subsequent events that he must have developed special competence in exposition and indulged his gift in public speaking, for it is recorded that he was a competitor for a prize in oratory. The very same year he began public lecturing, which he followed as a personal interest with marked success through all other changes for more than fifty years.

His chief life's effort, however, was spent in teaching in established educational institutions and in scientific and civic endeavor growing out of these relations. His 276 titles, several of them books and monographs, furnish a measure of his productive scholarship. Immediately upon completing his college course at Cornell, he was engaged as a teacher of natural sciences in Wyoming Seminary, at Kingston, Pa., and while there he married Miss Alice Egbert.

After only a couple of years at this place near his boyhood home, he found opportunity to continue educational and scientific work in New York City. In that city and vicinity he gave more than a hundred lectures in schools and other institutions in the first year. This was followed by a year as instructor in geology at Vassar College, and several years in Cooper Union. In that time, also, he became secretary and editor of the New York Academy of Sciences and in 1887 published a history of the Academy, which to date is the most authoritative statement of its development dating from Colonial to recent times.

During this time also he came in close contact with the American Association for the Advancement of Science. He was local secretary of the first New York meeting in August, 1887. Thereafter he held many posts in that rapidly growing organization. He was local secretary for the Rochester meeting, 1892; secretary of the council, 1893; general secretary, 1894, and member of the executive committee or committee on policy for more than thirty years. In the meantime, also, he served with the late J. McK. Cattell and others on revision of the constitution and rules, and published a brief historical account of the association in SCIENCE (Vol. 59, 1924).

He was an active member of that organization through a critical period characterized by integration and realignment of expanding scientific interests. Thus he came to be intimately concerned with developments that led to the founding of the Geological Society of America out of the overflow from Section E, which still continued to operate. He was one of the thirteen original founders of the new Geological Society as already noted, and he with Dr. Alexander Winchell formulated its first constitution and by-laws. Soon thereafter, he became secretary of the Geological Society, and was its effective administrative head for sixteen years, serving through its early formative years and probably impressing on it more of his ideas than any other man. After his retirement from the secretaryship he was honored by election to the presidency in 1912, and later was the author of its only History, which was published under the title "The Geological Society of America, A Chapter in Earth Science History," New York, 1932.

At the age of 38, long before these later events, and close upon his engagements in New York City, Fairchild had accepted a call to the University of Rochester, where he was to spend the rest of his long life. He became professor of geology and natural history there in 1888–1896 and professor of geology, 1896–1920. For ten years he was secretary of the faculty, and for thirty years curator of the Geological Museum, containing the famous Henry A. Ward Collection of geological material. In 1920 he became emeritus professor. Thus for more than twenty years he had

lived in retirement from full academic service, but his activities other than teaching were continued and he was honored conspicuously at various times in these later years. A bronze portrait bust was presented to him in 1932 by the Rochester Academy of Sciences, and in 1938 he was honored by the first award of the Rochester Municipal Museum, which took the form of a silver medal for civic achievement.

Through all his active years he continued public lectures on geology and energetically pursued investigation in his favorite branch of that science, becoming an outstanding authority on glacial geology, especially the glacial history of his own state and adjacent region. He was an official member of the New York State Geological Survey for many years and was author of several of its bulletins.

Professor Fairchild was an exceedingly active and influential man. He was widely known for his enthusiastic earnestness and evident confidence in the worthwhileness of his undertakings. No one who saw his powerful figure in action in his prime would have imagined that he had been physically frail as a child. Yet that is in the record. With the passing of youth, however, aided doubtless by his persistence in out-of-door life and in following his geological field studies, he had grown greatly in physical strength and in like measure in intellectual power. His presence was encouraging and he was welcome wherever he went. He always had an interesting contribution to make, and usually made it with telling effect. In a controversy or conference he was habitually on the winning side. But his influence was always thrown to the side that stood for orderliness and for serious-minded cooperation and for sound service in the public interest, no matter what difficulties had to be faced.

He was a born teacher with a distinct flair for popularizing. He was a far-sighted organizer and an adviser of unusual competence. He has left an indelible mark greatly to his own credit and much to to the benefit of at least four outstanding scientific organizations of this country—the American Association for the Advancement of Science, the Geological Society of America, the New York Academy of Sciences and the Rochester Academy of Sciences, and they have all lavished honors upon him. He served one of the outstanding colleges of university grade for more than fifty years, helping materially in giving it high standing in science—in the meantime making steady contribution to a better knowledge of his special branch of geologic science.

The writer of this brief note has special reason to feel his loss, for Fairchild was his earliest predecessor in one of these fields. Three years ago, in honor of his ninetieth birthday, the Geological Society presented him with a volume of letters to which he made response under date of May 1, 1940, in the following terms, "In the flood of messages and gifts, anent April 29th, the choicest and most highly appreciated is the handsome volume of letters from the Fellows of the Geological Society. This is the capstone of my scientific monument. For this I am deeply grateful to you. And I send thanks and appreciation to your office aids and the writers of the letters." By this time Professor Fairchild's physical disabilities interfered with his own reading. But of this he wrote: "with great pleasure I have listened to the reading of these cherished messages. Memory is quickened by the mention of old-time happenings, and emotion is stirred by the words of friendship, affection, approval, commendation and praise. I wish I could send personal individual reply to each writer."

Professor Fairchild long outlived the closest associates of his active days. A new generation has come into full possession of the fields since his formal retirement. He belonged to a period in which the public was beginning to take live interest in geologic science, and, to a large following, he was its prophet. He belonged to a time, also, when there was a growing need of conference and discussion. Investigation blazed with discovery. Principles were formulating. New forces were becoming engaged in factual search and the urge for meetings-together became a compelling force. In this situation Fairchild's special abilities came into fortunate relation and his talents were applied with telling effect.

He is survived by his second wife, Minnie C. Michael, whom he married in 1924, and two daughters, four grandchildren, and one great-grandchild.

In memory of a poetically gifted daughter, who died in early womanhood, the Lillian Fairchild Fund was established by him, providing an annual award to a young artist poet or writer. His own works are his memorial—these together with the affection lingering in the hearts of those who had listened to his vibrant voice and who had fallen under the spell of his impressive personality and had caught his message.

CHARLES P. BERKEY
COLUMBIA UNIVERSITY

DEATHS AND MEMORIALS

DR. CHANCEY JUDAY, since 1931 until his retirement with the title emeritus three years ago professor of limnology at the University of Wisconsin, died on March 29 at the age of seventy-two years.

DR. KURT LAVES, associate professor of astronomy, emeritus, of the University of Chicago, died on March 25 in his seventy-eighth year.

DR. ROBERT ANTHONY HATCHER, who retired in 1935, after serving for twenty-seven years as pro-

fessor of pharmacology at the Cornell University Medical School, New York, died on April 1. He was seventy-six years old.

DR. JOHN RICHARD FAIN, for thirty-one years head of the department of agronomy of the University of Georgia, died on March 26 at the age of seventy years.

A PORTRAIT plaque of the late Dr. Jabez H. Elliott, professor of the history of medicine of the faculty of medicine of the University of Toronto, has been unveiled in the building of the Toronto Academy of Medicine.

THE American Section of the Society of Chemical Industry and the New York Section of the American Chemical Society held a joint meeting on March 31 in commemoration of "Lavoisier, the Father of Modern Chemistry." Dr. Foster Dee Snell, chairman of the American Section, presided.

SCIENTIFIC EVENTS

NEW FELLOWS OF THE ROYAL SOCIETY OF EDINBURGH

IT is reported in *Nature* that the following have been elected ordinary fellows of the Royal Society of Edinburgh: John Anthony, lecturer in botany, University of Edinburgh; Dr. Daulatrai Bhatia, senior lecturer in zoology, Government College, Ludhiana, India; Professor David Burns, department of physiology, University of Durham; John G. Carr, cancer research worker, Institute of Animal Genetics, University of Edinburgh; Dr. R. W. Craig, Scottish secretary, British Medical Association; Dr. L. J. Davies, lecturer, department of medicine, University of Edinburgh; Professor E. M. Dunlop, department of bacteriology, University of Durham; J. M. Geoghegan, president of the Society of Accountants of Edinburgh; The Honorable Lord Gibson, chairman of the Scottish Land Court; J. Methuen Graham, surgeon, Edinburgh Royal Infirmary; Professor Arthur Holmes, department of geology and mineralogy, University of Edinburgh; Dr. D. J. A. Kerr, lecturer on forensic medicine, School of Medicine of the Royal Colleges, Edinburgh; Professor J. R. Learmonth, department of surgery, University of Edinburgh; Dr. W. Ledermann, assistant lecturer and Carnegie fellow, University of St. Andrews; Dr. A. D. McEwen, chief bacteriologist, Moredun Institute Animal Diseases Research Association, Midlothian; Dr. Robert McWhirter, lecturer in radiology, University of Edinburgh; Major Noel Ewart Odell, Clare College, Cambridge; Dr. R. F. Ogilvie, lecturer in pathology, University of Edinburgh; Professor G. D. Preston, department of physics, University College, Dundee; W. S. Procter, regional engineer, Post Office Engineering Branch, Scottish Region; Dr. T. Robertson, district geologist, H. M. Geological Survey, Edinburgh; Dr. R. W. Scarff, reader in morbid anatomy, University of London; E. Openshaw Taylor, lecturer in electrical power and machinery, Heriot-Watt College, Edinburgh; Dr. O. A. Trowell, lecturer in human physiology, University of Edinburgh; Professor J. Stirling Young, department of pathology, University of Aberdeen.

THE INTER-AMERICAN WORK OF THE AMERICAN STANDARDS ASSOCIATION

IT is reported in *Industrial Standardization* that Cyrus T. Brady, Jr., and Alberto Magno-Rodrigues, of the American Standards Association, are now traveling through Latin America. Mr. Brady is general field representative and Mr. Magno-Rodrigues is in charge of the inter-American work of the association in the New York office. They are making a survey of the field as a basis for the coming year's work in inter-American standardization. Through such contact it will be possible to determine what direction our efforts must take in the light of current conditions, to improve, develop and extend the work of the department.

In each country they will interview those most interested in standardization. They will consult with the directors of existing standards organizations, government executives, the heads of technical and scientific colleges and associations, industrialists and representatives of United States firms in Latin-America.

On his way to Brazil, Mr. Magno-Rodrigues spent several days in Venezuela. He received a very cordial welcome from executives of the Venezuelan government, the Commercial and Industrial Association of Venezuela and members of United States concerns. A full description of his visit appeared in the newspapers of Caracas.

Mr. Magno-Rodrigues met with Mr. Brady and with Mr. M. E. Souza, field representative for Brazil, in Rio de Janeiro. Following this meeting Mr. Brady visited Colombia, Venezuela and Chile on his way back to New York, where he conferred with the American Standards Association regarding further coordination of the work of home and field offices on the basis of the first year's experience. He planned to visit several countries on his way back to Argentina.

It is hoped that, as a result of these journeys, a thorough picture will be gained of the present status of standardization in the various countries, so that the Inter-American Department of the American Stand-

ards Association can extend its exchange of information and material regarding proposed and existing standards with the Latin-American standardizing organization and provide an increasingly thorough channel through which inter-American standardization can be developed.

THE PUBLIC SCIENCE CENTER AT HOUSTON, TEXAS

THE Houston, Texas, Parks and Recreation Department has announced the establishment of a post-war Public Science Center, in Hermann Park, with preserves in Memorial Park. Plans include, according to *Museum News*, the erection of a museum of science at a cost of $4,000,000, an aquarium and a planetarium each to cost $600,000, the complete replanning of the Zoological Park at a cost of $500,000, and a botanical garden, arboretum and wild-life sanctuary, for which the sum of $300,000 will be expended.

It is expected that funds for the project will be raised largely by public subscription. A finance committee of civic leaders has been set up. According to the statement:

> Steps toward the establishment of the science center were taken in the summer of 1943 by the new director of the Parks and Recreation Department, C. C. Fleming. Mr. Fleming appointed Victor A. Greulach, associate professor of biology at the University of Houston, who is also acting director of the Museum of Natural History, to develop a natural history program for the department. A Nature Committee was formed as an advisory planning group. Its eleven members are representatives of the Outdoor Nature Club, Boys and Girls Scouts, public and private schools, the university, and other organizations. The committee put into immediate effect a natural history program for 1943, began to lay plans for a larger program in 1944, and took the first steps toward the establishment of the center.
>
> Leadership and instruction were provided in Houston playgrounds. A Nature Guide School was conducted during July and August for playground directors and others interested. A nature trail was prepared in Hermann Park, and several playgrounds made their own nature trails. Steps were taken toward the establishment of a community forest. Ten volunteer experienced curators, under the direction of Valentine Gesner, curator of the Museum of Natural History, redecorated the museum and rearranged its collections and exhibits.
>
> On November 19, 20 and 21 the first annual nature fair was held to call attention to the work of the department. Exhibits were nature collections and craft work by playground and school children, together with material from city and state organizations interested in conservation and natural history. There were motion pictures, woodcraft demonstrations and campfire singing. It is estimated that twenty to thirty thousand visitors were in attendance.
>
> The program will be much enlarged in 1944. Nature trails and trailside museums are to be constructed in all the principal parks. The nature-guide school will become a year-round School of Natural History, affiliated with the university for college credit. The natural history book collection of the public library will be expanded.

THE BROOKLYN BOTANIC GARDEN

THE thirty-third annual report of the Brooklyn Botanic Garden calls attention to the various ways in which the garden has assisted in the war program during the past year. As part of this service are mentioned the courses in victory gardening and public lectures on textiles and on canning and preserving; conservatory exhibits of rubber-yielding, fiber and beverage plants; cooperation with the New York Victory Garden Council and the Civilian Defense Victory Organization by consultation and lectures; demonstration victory gardens planted in a conspicuous place in the garden and viewed by thousands of visitors each week; the showing of sound films on victory gardening; a war-bond rally; the sale of defense stamps and bonds in the garden on Sundays throughout the summer; the gift of a hundred conservatory plants to the Brooklyn Navy Yard; eighty-two trees and shrubs for beautifying the grounds of the Halloran General Hospital, Staten Island; and flowers and plants for other metropolitan hospitals. More than 1,300,000 packets of seed were distributed to school children.

Attendance on the grounds was 1,465,790—slightly less than that of last year, but the attendance at the conservatories—152,578—was much greater than for many years. The combined attendance at classes and lectures for children and adults was 96,672, a considerable increase over that of last year.

Reports on research in disease resistance in the cereal grains and in the chestnut tree, on flower structure in the dicotyledons, on the flora of Western Ecuador and Peru, on North American and South American Cyperaceae and on the physiological effect of various substitute teas are included.

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

THE thirty-fifth annual meeting and war conference of the American Phytopathological Society was held at the Neil House, Columbus, Ohio, from December 4 to 6, 1943. This annual meeting and war conference facilitated an exchange of ideas, facts and methods by members from various laboratories, universities, experiment stations and commercial concerns in North America. Comments indicate that this was one of the better meetings, as measured by the interest in the papers presented and discussions during the entire three-day meeting. The attendance was approximately 200. Fifty-eight papers reporting the results of orig-

inal research were presented in sections entitled "Preventive Fungicides," "Fungous Diseases and Growth Response," "Bacterial and Virus Diseases," "Soil and Seed Treatments" and "Eradicant Sprays."

In addition to these papers, there were round-table conferences. The subjects included were "The Emergency Plant Disease Prevention Program," "Vegetable Seed-borne Diseases," "War Committee Activities and Plans," "Copper and Organic Fungicides," "Extension Work in Plant Pathology" and "Cooperative Seed Treatment Tests." Interest in these conferences was high, with most members in attendance contributing to the discussions.

Officers of the society for 1944 are:

President, J. J. Christensen, University Farm, St. Paul 8, Minn.

Vice-president, J. B. Kendrick, University Farm, Davis, Calif.

Secretary, C. C. Allison, the Ohio State University, Columbus 10, Ohio.

Treasurer, R. M. Caldwell, Purdue Agricultural Experiment Station, West Lafayette, Ind.

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM DAVID COOLIDGE, vice-president and director of research for the General Electric Company, and Peter Kapitza, director of the Institute for Physical Problems of the Academy of Sciences, U. S. S. R., have been awarded Franklin Medals for 1944 by the Franklin Institute, Philadelphia. The award to Dr. Coolidge is "in recognition of his scientific discoveries, which have profoundly affected the welfare of humanity, especially in the field of the manufacture of ductile tungsten and in the field of improved apparatus for the production and control of x-rays." The award to Dr. Kapitza is in recognition of the invention of a method of producing extraordinarily high magnetic fields, many times greater than were previously thought possible, and the development of ingenious methods for making magnetic measurements of various kinds upon small pieces of matter exposed for a small fraction of a second to such fields. He also designed and constructed a machine for making liquid air and liquid hydrogen which is much more efficient than any machine yet developed. The medals will be presented at the annual Medal Day ceremonies to be held at the Franklin Institute in Philadelphia on April 19.

THE first awards of the Civilian Medals for Merit, in recognition of "exceptionally meritorious conduct in the performance of outstanding services," were presented on March 28 on behalf of the Government by Secretary of State Cordell Hull, chairman of the Medal for Merit Board. Those receiving the awards were John C. Garand, head engineer of the U. S. Army Ordnance Department, in recognition of his development of the rapid fire Army rifle which bears his name, and to Dr. Albert Hoyt Taylor, chief physicist of the Naval Research Laboratory, in recognition of his work which resulted in the discovery and development of radar.

AT a ceremony held at the University of Pennsylvania Club in New York City on March 31 the annual William Guggenheim honor cup was presented to Dr. Stuart Mudd, professor of bacteriology at the university, for his work in developing methods of drying blood plasma.

IT is reported in the *Journal* of the American Medical Association that Dr. Wallace E. Herrell, assistant professor of medicine at the University of Minnesota Graduate School, Rochester, has been presented in recognition of his work on penicillin with the distinguished service key of the Rochester Junior Chamber of Commerce for "outstanding service in 1943."

JUNIUS DAVID EDWARDS, assistant director of research of the Aluminum Research Laboratories, was recently named recipient of the Pittsburgh Award by the Pittsburgh Section of the American Chemical Society "in recognition of his distinguished service to chemistry, through his fundamental contributions in the fields of gas chemistry, the chemical and physical metallurgy of aluminum and aluminum paint, and the practical application of these developments for the betterment of mankind through his activities as inventor, author and editor."

DR. GEORGE C. DUNHAM, director of laboratories of the Army Medical School at Washington, executive vice-president of the Institute of Inter-American Affairs and assistant coordinator in charge of the department of basic economy, has been awarded the Southern Cross by the Brazilian Government.

DR. ARTHUR C. COPE, associate professor of chemistry at Columbia University, will receive the Award in Pure Chemistry of $1,000 for 1944 of the American Chemical Society in recognition of "outstanding research in organic chemistry," especially in the field of plastics and drugs. The prize, which is provided by Alpha Chi Sigma, was founded in 1931 by the late A. C. Langmuir to encourage fundamental research by young chemists working in North America.

AT its fiftieth anniversary convocation the Illinois Institute of Technology conferred the honorary doctorate of engineering on Dr. Willard H. Dow, president of the Dow Chemical Company; on Dr. James A. Rafferty, president of the Carbide and Carbon Chemi-

cals Corporation, and on Dr. Charles F. Burgess, president of the C. F. Burgess Laboratories, Inc., New York City.

IT is reported in *The Times*, London, that at a congregation of the University of Cambridge on March 11 the honorary degree of M.A. was conferred upon Daniel Georges Edouard Cordier, formerly professor of physiology at the Ecole Nationale Vétérinaire d'Alfort of the University of Paris. W. K. C. Guthrie, of Peterhouse College, "welcoming to our society a gifted scientist, a strenuous ally and a kindly friend," spoke on the fame of M. Cordier in his own country and his attainments in all branches of physiology, and especially in that of respiration.

DR. CHARLES HERBERT BEST, professor of physiology at the University of Toronto, has been elected a member of the Athenaeum Club, London.

DR. DAVID P. BARR, professor of medicine at Cornell University Medical College, has been named president-elect of the American College of Physicians.

THE officers of the Society of Vertebrate Paleontology elected for the year 1944–45 are: *President*, Dr. Glenn L. Jepsen, Princeton University, and *Secretary-Treasurer*, Dr. Edwin H. Colbert, the American Museum of Natural History.

THE American Society of Plant Taxonomists has elected the following officers for 1944: Dr. William R. Maxon, *President;* Dr. Philip A. Munz, *Secretary-Treasurer,* and Dr. Henry A. Gleason, *Chairman of the Council.*

THE International Association for Dental Research at its recent meeting in Chicago elected the following officers for 1944–45: *President*, H. Trendley Dean, U. S. Public Health Service; *President-elect*, Wallace Armstrong, University of Minnesota; *Vice-president*, S. W. Chase, Western Reserve University.

THE title of professor emeritus has been conferred on Sir John Ledingham, F.R.S., on his retirement from the chair of bacteriology of the Lister Institute of Preventive Medicine of the University of London.

PROFESSOR W. H. PEARSALL, F.R.S., who has held the chair of botany of the University of Sheffield since 1938 and is at present dean of the faculty of pure science, has accepted an invitation from the University of London to become Quain professor of botany at University College.

DR. A. R. TODD, F.R.S., professor of chemistry and director of the chemical laboratories of the University of Manchester, has been appointed professor of organic chemistry at the University of Cambridge as from September, 1944.

ODELL JULANDER, of the department of forestry of Iowa State College, has been named chief forester and associate professor of forestry at the University of Arkansas.

DR. EDWIN R. HENSON, regional agricultural analyst of the Bureau of Agricultural Economics of the U. S. Department of Agriculture, has been made chief of the division of agricultural rehabilitation of the United Nations Relief and Rehabilitation Administration.

DR. IRVING GRAEF, Major, M.C., on leave of absence as associate professor of pathology at the College of Medicine of New York University and as pathologist in the Bellevue Hospital, New York, has been appointed director of the Medical Research Laboratory at Dugway Proving Ground, Tooele, Utah. This laboratory is an installation of the Medical Division of the Office of the Chief of Chemical Warfare Service.

DR. BENNETT F. AVERY, dean of the School of Medicine of Boston University, has resigned to accept an appointment as director general of public health of Iran.

DR. EMMELINE MOORE, chief aquatic biologist, director of the Biological Survey of the Conservation Department of New York State, who has served in this capacity for twenty-five years, retired on March 30.

IT is reported in *The Experiment Station Record* that Edward L. Tanner has been assigned to the Cooperative Experiment Station in Nicaragua to conduct agronomic work on coconuts, sesame and other oil-yielding plants, on rice, and on abacá, a source of fiber. He will establish demonstration plantings on private farms and assist in training Nicaraguan personnel at the station. Benjamin Y. Morrison, principal horticulturalist in charge of the Division of Plant Exploration and Introduction of the Bureau of Plant Industry of the U. S. Department of Agriculture, is assisting in the coordination of the agricultural research program in Colombia, especially as it relates to the production of cinchona.

DR. MARSHALL KAY, associate professor of geology at Columbia University, has been appointed special lecturer to visit the various local sections of the American Association of Petroleum Geologists. He is visiting some fifteen chapters during the spring giving lectures on "Geosynclinal and Continental Development."

DR. RICHARD E. SHOPE, a member of the Rockefeller Institute for Medical Research in the department of animal and plant pathology at Princeton, N. J., commander in the U. S. Naval Reserve, delivered at the Johns Hopkins Hospital on March 16 and 17 the fourteenth course of lectures under the William Sydney Thayer and the Susan Read Thayer lectureship in clinical medicine. His subject was "Old, Intermediate

and Contemporary Contributions to Our Knowledge of Pandemic Influenza."

DR. WILLIAM E. SHOUPP, manager of the Electronics Department of Westinghouse Electric and Manufacturing Company, gave on March 17 at Miami University a lecture on "Nuclear Physics" under the auspices of Sigma Xi and Sigma Pi Sigma. In addition to faculty and civilian students, approximately 200 V-12 students were in attendance.

THE ninth annual Harrison S. Martland Lecture of the Essex County Anatomical and Pathological Society was given at the Academy of Medicine of Northern New Jersey, Newark, on March 22 by Otto Loewi, research professor of pharmacology at the New York University College of Medicine.

DR. E. B. COWDRY, professor of anatomy of the Washington University School of Medicine, St. Louis, addressed the Los Angeles Academy of Medicine on March 3. His subject was "Precancerous Lesions."

THE Georgia Section of the American Chemical Society held a special meeting in LaGrange on March 18, under the auspices of Callaway Institute, Inc. The meeting was arranged to permit the members of the society to attend a lecture on "The Chemical Structure of Textile Fibers" by Dr. Milton Harris, director of research for the Textile Foundation of Washington, D. C., who was visiting the institute at that time. In addition to the lecture, there was an inspection tour of the institute, a visit through one of the weaving plants of the Callaway Mills, and a dinner for visitors.

THE New York Medical College has recently received gifts in memory of John Eastman Wilson from Mrs. Wilson. Dr. Wilson was professor of neurology and was associated with the college from 1902 to 1918. The sum of $100,000 is designated as a student loan fund for needy medical students and a second gift of $10,000 has been added to the endowment of the department of surgery.

CHEMICALS wanted by the National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Ill., include: straight-chain organic acids of 35 to 45 carbon atoms; Cytosine (approx. 10 grams); dl Camphenilone; Coniferyl alcohol; Cadion 2B (4-nitro-l-naphthalenediazo-p-amino azobenzene); 7-Dehydrocholesterol (1 to 10 kilos); Desoxyribose; Distearyl sulfone; Epicatechin (3,5,7,3′,4′-flavanpentol); d or l-galacto ascorbic acid; l-gluco ascorbic acid; Indazole; Alpha ketoglutaric acid; Phloridzin; Tetrophine (5,6-dihydro-1,2-benzacridine-7-carboxylic acid); Kynurenic acid, and Xanthurenic acid.

DISCUSSION

PEACETIME RESEARCH IN WARTIME—A REPORT

IN June, 1943, the following letter was sent to 212 zoologists now in active service with the armed forces:

Dear Colleague:

This letter is addressed to you, among others, as a fellow scientist who interrupted the pursuit of your chosen field in order to enter the Services. Many of us who, because of age or other circumstances, remain at home, are much torn between conflicting attitudes regarding the continuation of scientific and scholarly activities in the midst of war. Probably all of us are in some way part of the general war effort. We teach now nearly exclusively premedical and nursing students, and this serves the immediate preparation for their war-important professions. Many of us also participate in special war research projects of biological or physiological nature. Some of us do not seem to possess any skills which make us valuable as direct contributors to war research. The question in our minds is this: Should we devote every hour of our time to efforts of immediate war usefulness, or should we reserve a fraction for the continuation of the research lines which were thought fruitful in a more peaceful period? We see arguments for and against either alternative. When the roof is on fire, we feel, to put out the flames is the only task behind which everything else should disappear—but we wonder whether the analogy between the few inhabitants of a house on fire and a nation at war is correct enough to warrant the conclusion that we should stop all scholarly work. We feel that the permanence of peaceful human endeavors can be assured best if we devote some time to keeping them going in wartime—but we wonder if this sentiment is only an expression of egotistical desires, of our personal pleasure in such activities.

Obviously, the question can not be decided by vote. However, it seemed to me that an expression of the opinion of our colleagues now in the Services might be of help to us at home. You may not be unbiased either; perhaps you are even shocked by the fact that questions like the one raised in this letter are under discussion at all. Whatever your opinions, should you be able to spare the time, it would be of great help to us to hear them expressed. . . .

(Signed) CURT STERN

All names were obtained by writing to sixty-six departments of zoology and asking for a list of staff members and graduate students then in the services in order "to address to them some questions bearing on science." The sixty-six institutions were selected as likely to be concerned with research in normal times. Replies were received from forty-five departments distributed widely over the country. Of the 212 letters

sent to individuals, 13 were returned marked "no record." This leaves a maximum of 199 letters which may have reached their destinations. Replies were received from 42 men, a return of about 20 per cent. Whether this should be called a low return, considering the highly selected group of recipients, or a high return, considering the demands of military life, is uncertain. It is also unknown how representative this sample is of the opinions of all zoologists in the Armed Forces. Nevertheless, an analysis of the answers is of general interest.

Intentionally, the problem was not formulated as a questionnaire; consequently, the replies did not follow a simple pattern. The first overall impression is that of intense interest. Many replies were several pages long, few only half a page. The classification of all the opinions expressed involves some subjective element, mainly due to the fact that any useful classification entails a neglect of the many individual shades of conviction. Leaving out one letter which clearly did not touch the problem posed, four categories of opinion were distinguished regarding the continuation of some "peacetime" research. These opinions, together with the arguments given for them, may be summarized as follows (each of the following quotations comes from a separate letter):

(1) *Complete discontinuation.* It is argued that all but war research should be postponed in order to secure first the liberty which will make possible later the renewal of peacetime work. "The more completely this translation of effort becomes effected, the sooner victory is assured for forces in combat. There will be plenty of time when the war is over for non-essential, cultural pursuits."

(2) *Continuation but in spare time only.* Peacetime research should be continued even in wartime, the arguments run, but this work should be pursued when other men, including soldiers, rest from their day's labor. Free research is seen by some as of general intrinsic value, by others as a means of furnishing necessary refreshment to those who devote themselves full time to the war activities of teaching and/or war research. "Recreation is as indispensable in wartime as in peacetime. Who can blame the university teacher if he chooses to devote to fundamental research the time he might otherwise spend in listening to some frenzied radio news analyst?. . ."

(3) *Continuation, after self-searching inquiry as to the basic importance of the work.* Men expressing this opinion believe in the basic value of peacetime research as part of our civilization. They stress, however, the obligation of the scientist to test himself, his motives and his projects so as to carry out research as a responsibility to society. They demand selection of important problems, discontinuation of playful techniques and all-too-private interests. A decision will depend "on the importance of a man's research program and his abilities. A great many workers are "diddlers" . . . they might well devote their energy to the war effort. There are other men whose work in the field of pure science is extremely important and certainly these men should be allowed to continue their investigations." Scientists "should reexamine their individual research projects in the light of their value to the whole scientific framework of our civilization . . . strengthen their philosophy of science."

(4) *Unqualified continuation.* This term is applied both when the writer approves of setting apart a fraction of the investigator's time for peacetime work, and when even more time for research of this kind is favored. Such continuation is an essential part of what we are fighting for. "It seems . . . to be a glowing tribute to the American way of life that research . . . is being carried on *in spite* of the war." It is "part of the battle for the freedom of the mind." "Scholarship must not be put into the luxury class." Several writers take up the simile of the house on fire which was used in the letter to them. "It is wise to have some people protect the valuables in the house." Another opinion which occurs in six different letters states that men at home "should work toward maintaining a civilian standard of science and culture that men will be glad to come back to." "I know that I hope strongly to return to a laboratory where an active research program is under way." Finally, it is argued frequently, "that if we lay aside and forget our ideals for any lengthy period of time we may fail to assume them again when the appropriate time to do so returns."

TABLE 1

OPINIONS OF ZOOLOGISTS NOW IN THE ARMED FORCES CONCERNING PEACETIME RESEARCH

		Discontinuation	Continuation			Total
			In spare time	If important	Unqualified	
		4+2?	4+1?	3	26+1?	41
Academic status	Ph.D. degree	5	2	1	12	20
	No Ph.D. degree	–	2	1	7	10
	Unknown	1	1	1	8	11
Military rank	Commissioned officers	3	2	3	16+1?	25
	Enlisted men	3	3	–	10	16

A question mark signifies some doubt as to the correct classification.

Table 1 summarizes the number of replies in each category. It also contains some data on the peacetime

status of the writers and on their military rank. The majority of the answers came from men in this country, but those from overseas did not differ significantly from the whole group. Personal acquaintance of the writers with the author of this survey (eight cases) did not seem to influence the opinions expressed as shown by the fact that the answers were representatively distributed.

In summary, thirty-five of these forty-one zoologists now in the Armed Forces believe that peacetime research should be carried on in wartime, "in spite of war" and even with "redoubled efforts." Of these, five are for continuation in spare time, three with restriction to important problems, and twenty-seven for more or less unqualified continuation. Six men are against continuation. It would be of interest to know what the majority of men in other fields of science, of the humanities and in general think about the problem raised.

CURT STERN

DEPARTMENT OF ZOOLOGY,
THE UNIVERSITY OF ROCHESTER

THE 24-INCH OBJECTIVE PRISM OF THE WARNER AND SWASEY OBSERVATORY

ONE month before "Pearl Harbor," the 24-inch Schmidt-type telescope and the building addition to the Warner and Swasey Observatory of the Case School of Applied Science were completed. Plans for an objective prism for this instrument were executed in conjunction with the design of the mounting, and the Bausch and Lomb Company agreed to furnish us with a suitable disc of optical glass for this purpose. On December 12, 1943, the completed prism was finally mounted on the telescope and during the succeeding two months extensive tests were made with it.

The one-lump mass of glass for the disc was chosen from one of the pots of optical glass. The 260-pound piece chosen was free from deep striations and air bubbles. This huge mass, one of the most perfect ever produced, was molded to shape in a deep furnace utilizing a pot design to produce a wedge shape. The flat surfaces were then polished and the disc examined with polarized light. No strains were detected. Later tests showed that the annealing of the glass was excellent. The diameter of the finished disc, before being reduced in the optical shop, was 26.75 inches; the thickness varied from 3.0 to 4.3 inches. The refractive index of this light flint glass is 1.617 with dispersion ratio of 36.6.

The grinding and polishing of the prism was executed in a most satisfactory manner by C. A. Robert Lundin, of the Warner and Swasey Company. This firm has also constructed and erected the Schmidt-type Burrell telescope of the observatory and the dome.

The diameter of the finished prism is 24.5 inches, with clear aperture of 24.0 inches and with graduated thickness from 0.75 to 2.5 inches, producing an angle of 4 degrees. The finished prism weighs 100 pounds.

The prism cell mounting is so constructed that when in place it may be easily rotated through any desired angle in a plane perpendicular to the optical axis of the telescope. The cell with the prism forms a symmetrically balanced mass of 150 pounds. A 26-inch ring-weight of 150 pounds situated in front of the correcting lens is first removed from the telescope when the prism is to be mounted, thus avoiding any re-balancing of the instrument.

The optical system of the Schmidt telescope is composed of a 36-inch mirror of pyrex glass with aluminized surface and a 24-inch correcting lens of Vitaglass, 0.34 inch thick. The effective focal length of the instrument is 84 inches. The plate holder is circular and adapted for plates 8 inches in diameter yielding a field of 5°.

The combination of the prism and telescope produces spectra of 3.2 mm in length from H_β to H_ϵ.

The quality of the spectra appears excellent. In the spectrum of the F_5 star α Persei 21 lines in the region from H_β to H_{16} have been identified. Both focal images and spectral images are of excellent definition to the very edge of the plate.

The main program of the prism telescope combination will be the study of the structure of the galaxy through spectral type distributions and related problems. Plates already secured indicate that absolute magnitude classification as well as spectral types may be readily studied with these small scale spectra.

J. J. NASSAU

CASE SCHOOL OF APPLIED SCIENCE

DIGESTIVE AVAILABILITY OF BEAN STARCH

IN view of the present emphasis on the use of dried beans a brief account of some additional observations on digestive factors in navy beans may be of interest. It was recently found that the ether-soluble fraction of these beans retards the *in vitro* digestion of soluble starch more than some of the other edible fats. In an earlier note[1] attention was called to the interference which is observed when the total ether-soluble fraction is added to soluble starch in the same concentration in which it occurs in the beans or about 1.5 per cent.

Employing 1 per cent. solutions of soluble starch adjusted to pH 7 with phosphate buffer, further study has shown that various preparations of starch and navy bean oil differ in the ease with which they are completely digested when sufficient pancreatic amylase is added to digest untreated control starch or starch containing 1.5 per cent. of olive oil, lard or butter

[1] D. E. Bowman, SCIENCE, 98: 308, 1943.

within 30 minutes. Estimation of the amount of reducing sugars formed indicates that in the great majority of these artificial bean-oil preparations the undigested residue which is responsible for the positive starch-iodine test and which resists digestion for some hours after the control preparations are digested does not exceed 5 per cent.; however, in some cases this fraction was observed to be much greater. Sodium chloride was added to obtain maximum activity of the enzyme.

The reason for this variation and the relation of the ether soluble factor in the intact bean to the delayed digestion of bean starch is being studied further. The relative inaccessibility of the bean starch to *in vitro* digestion by pancreatic amylase is apparent when soaked whole beans are heated and crushed under conditions which more than suffice to render the starch of potatoes quite available. When digested as described with equal starch concentrations the difference in the amount of reducing sugars formed in the two cases is very striking. The starch of beans which are finely ground before cooking appears to be more easily digested than that of the beans which are cooked whole and then mashed.

Procedures other than prolonged heating employed in compensating for the delayed digestion include the well-known action of acids upon insoluble starch as well as treatment with yeast and enzymes of barley malt. While the yeast has many obvious advantages in adding desirable nutritional factors simple preliminary treatment with acid with subsequent neutralization appears to be more practical and efficient than the latter in accelerating the digestion *in vitro*.

DONALD E. BOWMAN
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DEMONSTRATION OF THE FORMATION OF A FILAMENT FROM TISSUE CONSTITUENTS IN VITRO

IT has been possible during the past four years to entertain visitors to this laboratory with an *in vitro* demonstration of what we have extravagantly termed a "nerve regeneration." A perfectly formed spiral filament can be precipitated from a phosphate extract of brain tissue when a direct current is passed through the material confined in a glass tube of small diameter. This demonstration has served to mystify the skeptics and impress the more gullible of my less scientific collaborators. The interest expressed justifies the recording of this phenomenon, which was first observed during the course of some experiments on the cataphoresis of a mixture of brain proteins.

The demonstration may be repeated as follows: 12 inches of glass tubing with an external diameter of approximately 3 mm (internal diameter may vary between 1 and 2 mm) is bent into a "U" tube approximately 5 inches tall. The tissue extract is prepared by taking one volume of brain cortex (freed of the more obvious blood vessels) and mixing with two volumes of .02 M phosphate buffer, pH 7.3, in a small mortar and pestle, where it is ground until it is quite homogenous. This mixture is centrifuged at 1,500 r.p.m. for approximately 15 minutes, or until the gross particles are separated from the supernatant extract. It is not necessary to centrifuge until the supernatant is perfectly clear. Some of this extract is transferred to the glass "U" tube with the aid of suction and 110 volts of direct current are applied to this mixture with the aid of platinum electrodes inserted in both ends of the "U" tube. The platinum electrodes are made from pieces of platinum wire, gauge No. 22. Contact between the solution and the platinum is made by inserting the wire a distance of 1/16 inch below the surface of the mixture. Shortly after the current is applied a small precipitate begins to form at the anode (acid-forming pole). This precipitate extends itself to form a thin filament which spirals down the tube to form what looks like a fine spring. The thickness of the filament will vary depending upon the strength of the current and the density of the tissue extract. Reversing the polarity of the current causes solution of the filament by the alkali formed at the cathode.

It has been possible to make these spiral filaments from the brains of rats, hogs, cattle, rabbits and man. Attempts to duplicate this phenomenon with tissue extracts from other organs have not been successful in the few trials attempted nor has it been possible to date to duplicate the experiment with solutions of purified proteins.

The filament formed has low tensile strength but with care can be removed from the glass tube. It is not pure protein but is a mixture of most of the components of the original extract.

The explanation of this phenomenon may depend in part upon the fact that the protein in solution in the brain extract is precipitated when the acid is formed at the end of the anode. The orientation of this precipitate into a spiral may be influenced by the shape of the vessel in which it is formed, the electrical field of force about the precipitate and the movement of the fluid in the container.

The biological significance of this demonstration can be almost anything the imaginative reader cares to imply. Additional work is indicated.

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SCIENTIFIC BOOKS

MEDICINE

A Hundred Years of Medicine. By C. D. HAAGENSEN and W. E. B. LLOYD. Pp. xii + 444. 42 illustrations. New York: Sheridan House, Inc., 1943. $3.75.

ANY good book has a personality which in turn implies a pleasant inheritance and a good upbringing. This particular book certainly has a substantial family tree and a sound educational background, for it represents an alliance between the two Cambridges—Cambridge, England, and Cambridge, Massachusetts. One of its authors, Dr. Haagensen, graduated from the Harvard Medical School, and the other, Dr. Lloyd, received his bachelor's and master's degree from the older university.

In 1936, Dr. Lloyd was induced to write a book called "A Hundred Years of Medicine." At that particular time the publishing house of Duckworth in London was putting out what it called the "Hundred Years Series." The books in this series dealt with such varied topics as psychology, transport, anthropology and government, and also included medicine. One gathers that their purpose was to describe for British readers a century of progress in several different fields.

Dr. Lloyd's book was 344 pages long, was unillustrated and sold for fifteen shillings. It must have created a favorable impression in England and have been well received by the medical profession there, since both the *Lancet* (135–136, July 18, 1936) and the *British Medical Journal* (392, August 22, 1936) at once spoke highly of it. Each of these critics emphasized that the book told the story of a century's history of medicine accurately and entertainingly and was certainly the kind of a volume that any one who cared for reading would enjoy.

Certain copies of it reached this country; apparently, however, not many medical men saw them. The book was not reviewed in such periodicals as the *Journal* of the American Medical Association, the *Archives of Internal Medicine* or other journals which are in the habit of reviewing medical books, and no copies of it are to be found in such representative literary lodging houses as the Boston Medical Library and Harvard University; yet certain physicians became acquainted with it because the New York Academy of Medicine owns a copy and there must be at least one copy in Philadelphia, since it was reviewed in the *American Journal of Medical Sciences* (194: 276, August, 1937).

On the whole, the American reception of Dr. Lloyd's book was anything but cordial. I have been unable to find any reviews of it by non-medical writers, and our doctors were equally indifferent. E. K. of the *American Journal of Medical Sciences* said that any one who digested it would be well informed on the progress of medicine in the past century; but in general too few doctors made its acquaintance to allow it to win the reputation it deserved.

As one rereads it, the first edition was a pleasant affair. It began with a quotation from Burton in "The Anatomy of Melancholy" and surely no more graceful introduction to a volume on the history of medicine is possible than his words: "How many excellent physicians have written just volumes and elaborate tracts of this subject? No news here: that which I have is stoln from others; *dicitque mihi mea pagina, fur es.* If that severe doom of Synesius be true, *it is a greater offence to steal* dead mens labours, than their cloaths, what shall become of most writers? I hold up my hand at the bar amongst others, and am guilty of felony in this kind." The book went on from this beginning to give an instructive and lively account of what has happened in the field of medicine from 1832 until 1934. The style was pleasing, the material that was used was diverse, and the manner in which it was presented was delightful. There was a timetable of events of medical importance at the end—in itself a useful compilation for any one to be able to lay hands on. On the whole, it is easy to see why our British colleagues spoke so favorably of the book and still difficult to understand why so few people on our side of the Atlantic accepted it.

The new edition which has just appeared includes the contents of the first edition brought up to date and also a good deal of extra material. It is now a collaborative enterprise and its two authors have dovetailed together each other's views so as to make an appetizing mixture of the whole for readers on either side of the Atlantic. When all is said and done, the last century was a fertile period for medicine; the chief difficulty for the authors was to decide what to leave out.

There are certain obvious gaps in the book which individual critics may seize upon. For example, the medical adventures of Alexis St. Martin were omitted, an oversight which the *Rhode Island Medical Journal* (26: 313, December, 1943) objected to, and the valuable timetable of significant medical events of the past century has been deleted. The majority of physicians who see it, however, will agree that here is a readable book worth reading and recommendable to their colleagues, friends and students.

It is nicely printed, well indexed, the illustrations which are scattered through the text are interesting,

the bibliographic references that accompany each chapter are well chosen, and the story is fascinating of how many advances in different and apparently unrelated fields of medicine have been correlated to advance knowledge. The final chapter gives a fair and impartial account of the current trend towards the socialization of medicine.

The second edition of "A Hundred Years of Medicine" bids fair to achieve the general popularity it deserves. After a seven-years' sleep, and in a new dress, at last the book will come into its own.

REGINALD FITZ

CALCULUS

Calculus. By LYMAN M. KELLS. Prentice-Hall. $3.75.

PROFESSOR KELLS'S attractive new book can be warmly recommended as an introduction to the calculus. He has given real life to the fundamental abstract ideas, by well-chosen and often original verbal and pictorial illustrations (there are 325 figures). In the same spirit, he has driven home the practical value of the calculus as a method by an immense variety of concrete problems. The result should be to embed the calculus permanently in the thinking processes of even mediocre students, and the reviewer intends to try the text in his own first-year courses.

On the other hand, he does not feel that Professor Kells's book will develop sufficiently the critical ability of more advanced students. No warning is given that one may be led into error by believing the "obvious," and no apology is made for introducing convenient "assumptions" in order to minimize the difficulties of proof. In fact, the "proof" at the top of page 409 is grossly wrong; so is the "assumption" at the beginning of §174; the function $\exp(-1/x^2)$ being a well-known counter example which appears in most rigorous texts. When such errors are corrected in later editions together with numerous misprints, the book should be admirably suited to first-year students.

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SPECIAL ARTICLES

THE RED AND GREEN LIGHTS OF THE "RAILROAD WORM"

A FEW luminous animals are known which emit light of two different colors. One of the most striking of these is the South American railroad worm or "ferrocarril," of the genus, Phryxothrix, a beetle of the family Phengodidae, related to fireflies. The adult male has typical beetle characteristics and long branched antennae. The adult female, nearly two inches long, is larviform, with eleven pairs of brilliant greenish yellow luminescent spots on the sides of the body and a red luminous area in the head. The larvae of both male and female also possess similar luminescent spots. In North America, the rare closely related insect, Phengodes, occurs, with rows of green lights, but lacking the red light in the head.[1]

Thanks to the kindness of Dr. H. L. Parker, of the U. S. Department of Agriculture, I have recently received from Uruguay several living specimens of Phryxothrix in excellent condition. One was an adult female and the others probably larvae. They showed no light when at rest but if disturbed very slightly, by knocking the table gently or blowing air over them, they responded by shining the red light. When the disturbance was greater the rows of greenish lights also appeared and the animal explored its environment with a brilliant display of pyrotechnics. The red light in the head resembled the tip of a glowing cigarette. Sometimes all and sometimes only certain of the greenish lights would be turned on. Later the greenish lights went out while the red remained on for some time, finally to disappear as the animal became quiet again.

With these specimens it has been possible to determine the nature of the red luminescence. There are three ways in which a red light might be produced: (1) By emission of red wave-lengths, a red chemiluminescence; (2) by the presence of a red color screen transmitting red but absorbing other wave-lengths; (3) by red fluorescence of a compound, excited by shorter wave-lengths emitted by some chemiluminescent reaction. The first method is the one used in producing the red light, as indicated by the following experiments.

If the red luminescent material is dissected out of the head of Phryxothrix and examined on a slide in day-light, no red pigment can be detected.[2] The tissue appears colorless and the easily visible (in the dark) red luminescence could not be due to a red color screen or to absorption by the chitin of the head, which is a light brown in color.

When hydrogen or nitrogen gas is passed over the excised red luminescent tissue in the dark, the red light disappears, and if the potentially luminous substance is now exposed to near ultra-violet light without the visible (from a mercury arc filtered through Wood's

[1] See the description in "Living Light," by E. N. Harvey, Princeton University Press, 1940, p. 69.

[2] A very weak solution of some red compound might be present, too dilute to appear red by absorption but concentrated enough to luminesce with a red emission. The luminescence of colored compounds can be detected in concentrations too weak to appear colored.

nickel glass), no red fluorescence can be detected. Since this near ultra-violet light is especially active in exciting fluorescence of a wide variety of organic compounds, we can conclude that the red luminescence is not a fluorescence.

When oxygen is readmitted to the luminous organ the red luminescence reappears, indicating that the red light is a red oxidative chemiluminescence comparable to that resulting from oxidation of Mg and Zn complexes of certain porphyrins, phthalocyanines and chlorophyll derivatives, as described by a mumber of investigators.[3] Although no red pigment is visible in the luminous tissue, a red pigment is present in the body of Phryxothrix. It is not known whether this pigment is a porphyrin or whether it is concerned in light production.

The light of the greenish luminescent organs also disappears in absence of oxygen and returns in its presence, as does the luminescence of the firefly and many other luminous animals in which the light is also an oxidative chemiluminescence. It is futile to speculate concerning the nature of the luminous substance responsible for the red and green luminescences in the same animal. Indeed the mechanism of luminescence in the fireflies and related insects needs further investigation. There is some evidence that the luciferase-luciferin system is actually an enzyme-coenzyme system, as I have previously suggested.[4] A more abundant supply of this rare and fascinating South American beetle would greatly aid in clearing up some of the chemical aspects of bioluminescence.

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IDENTIFICATION OF THE FLUORESCENT SUBSTANCE F_2[1]

IN 1940 Najjar and Wood[2] described the presence of a fluorescent compound obtained from urine eluates after treatment with the alkali and butanol, which was dependent on the intake of nicotinic acid.

This substance, subsequently designated F_2, was unobtainable from the urine of pellagrins[3] and animals with black tongue,[4] a fact which has been made the basis of a useful test for identifying nicotinic acid deficiency.[5] The chemical nature of F_2 has been investigated in this laboratory[6] and elsewhere.[7-11] We reported striking similarities to the fluorescent reduction products of N-methyl nicotinamide. In a simultaneous and a subsequent report[8, 9] Huff and Perlzweig prepared N-methyl chloro-nicotinamide and claimed that F_2 could be identified as N^1-methyl nicotinamide, an obvious error in view of the fact that solutions of N-methyl chloro-nicotinamide are non-fluorescent.

It appears certain, however, that the precursor of F_2 is a derivative of N-methyl nicotinamide, since we have obtained the same fluorescent compound F_2 both from urinary eluates and from aqueous solutions of the chloro-, bromo- and iodo-derivatives of N-methyl nicotinamide. The final product is free from halide, indicating that alkali treatment displaces the anion of the F_2 precursor, thus obscuring its identity. Huff and Perlzweig showed that picrates made from urinary eluate and from N-methyl chloro-nicotinamide had identical melting points (189.5° C), a finding we have confirmed. This method of approach, however, does not shed any more light on the nature of the anion which is displaced by picric acid. We have prepared halogen-free picrates from N-methyl chloro-, bromo- and iodo-nicotinamide that were identical with that obtained from the F_2 precursor in urine eluate in individual and mixed melting points (189.5° C). It is, however, possible that treatment with picric acid may detach some substituent group at another portion of the molecule than that occupied by the halide. The identity of the picrates therefore does not prove that their precursors were identical. In this connection it is of interest to note that Coulson and Ellinger,[10, 11] although they confirmed the identity of the picrate from urine and from N-methyl chloro-nicotinamide, obtained an aurate from these two sources which differed both in color and melting point. For the present, therefore, the identification of the non-fluorescent precursor of F_2 remains incomplete.

The present communication deals with the chemical changes concerned in the conversion of the non-fluorescent precursor into the fluorescent F_2. Studies of N-methyl pyridines as well as N-methyl quinolines and acridines[12, 13] have shown that a quaternary pyridinium base is first formed which, by rearrange-

[3] See P. Rothemund, *Jour. Am. Chem. Soc.*, 60: 2005, 1938, and J. H. Helberger and D. B. Hever, *Ber. d. d. Chem. Ges.*, 72B: 11, 1939.

[4] E. N. Harvey, SCIENCE, 44: 652, 1916.

[1] The work described in this report was carried out under a grant from the Williams-Waterman Fund of the Research Corporation.

[2] V. A. Najjar and R. W. Wood, *Proc. Soc. Exp. Biol. and Med.*, 44: 386, 1940.

[3] V. A. Najjar and L. E. Holt, SCIENCE, 93: 20, 1941.

[4] V. A. Najjar, H. J. Stein, L. E. Holt and C. V. Kabler, *Jour. Clin. Invest.*, 21: 263, 1942.

[5] L. E. Holt and V. A. Najjar, *Journal-Lancet*, 63: 366, 1943.

[6] V. A. Najjar, D. B. M. Scott and L. E. Holt, SCIENCE, 97: 537, 1943.

[7] J. W. Huff and W. A. Perlzweig, SCIENCE, 97: 538, 1943.

[8] J. W. Huff and W. A. Perlzweig, *Jour. Biol. Chem.*, 150: 395, 1943.

[9] R. A. Coulson, P. Ellinger and B. S. Platt, *Biochem. Jour.*, 36: 12, 1942.

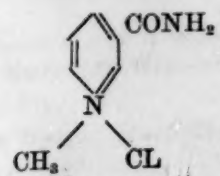
[10] P. Ellinger and R. A. Coulson, *Nature*, 152: 383, 1943.

[11] R. A. Coulson and C. Ellinger, *Biochem. Jour.*, 37: 17, 1943.

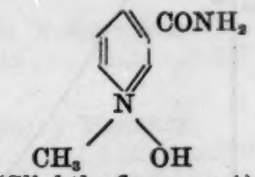
[12] E. Decker and A. J. Kaulfmann, *Pract. Chem.* (2) 84: 432, 1911.

[13] Taylor and Baker, "Sidgwick's Organic Chemistry of Nitrogen," p. 524, Clarendon Press, Oxford, 1937.

ment, is in large part converted into a carbinol. Such carbinols combine readily with alcohols to form carbinol-ethers. In the case of N-methyl chloro-nicotinamide, when treated with alkali and isobutanol, the reactions would be as follows:



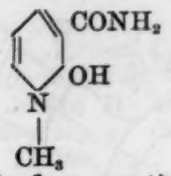
(non-fluorescent)
Quaternary salt



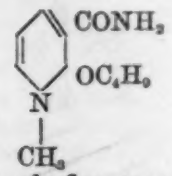
(Slightly fluorescent)
Quaternary base

Upon treatment of purified urinary eluate and of N-methyl chloro-nicotinamide with alkali, fluorescence develops at once, though consistently more rapidly with the former. The absorption spectra of both products are nearly identical (max. 264 μ, min. 250 μ). We were led to the conclusion that the resulting carbinol must form a condensation product with the alcohol from the observation that minute additions of isobutanol to the alkaline carbinol solution, insufficient to cause separation of an alcohol layer, caused nevertheless a very striking increase in fluorescence. The formation of a carbinol-ether is not an instantaneous reaction, but continues to progress even after an isobutanol extract has been made,[2] which explains the hitherto puzzling increase in fluorescence on standing. When the isobutanol extract is evaporated to dryness the carbinol-ether is broken down, leaving the carbinol itself.

We have prepared highly concentrated F_2 solutions which were evaporated to dryness yielding a waxy yellowish solid which could be crystallized from methanol. The elementary analysis of these crystals was found to correspond with the formula of the carbinol with the exception that the nitrogen content was only half as great. The latter finding was anticipated in view of the prolonged alkali treatment which was noted to liberate ammonia, presumably from hydrolysis of the amide. The elementary analyses of our product obtained from urine and the theoretical values of the carbinol of N-methyl nicotinic acid, are as follows:



(Slightly fluorescent)
Carbinol



(Very strongly fluorescent)
Carbinol-ether = F_2

	N	*C*	*H*
Product from urine	9.7	58.1	7.2
N-methyl nicotinic acid carbinol	9.1	54.0	6.0

In conclusion we feel that the complete structure of the F_2 precursor is not yet established, although it appears certain that it is a derivative of N-methyl nicotinamide. The highly fluorescent compound F_2 formed from this precursor on treatment with alkali and butanol appears to be a butyl ether of N-methyl nicotinamide α-carbinol.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLIFIED LYOPHIL APPARATUS

THE lyophil apparatus described here is a compact and efficient piece of equipment which has proved very satisfactory for small-scale laboratory work. As shown in Fig. 1, the diffusion path of water vapor is short and the cross sectional area is large. The outer jacket has one small opening (A) at the top for evacuating the inner chamber and four openings (B) in the lower portion to which drying flasks are attached. These openings are made with standard taper 34/45 short female ground glass joints. The apparatus in Fig. 1 shows three joints on the side and one at the bottom. The dimensions given here are large enough to accommodate four flasks instead of three on the side if desired. There may also be some advantage in having the joints come off at a downward angle.

The flasks used are pear-shaped in order to facilitate removal of dried material. They are fitted with 34/45 male short joints. The joints are sealed with a film of stopcock grease. The condensing surface (C) is tapered in order to permit accumulation of a greater volume of ice. The apparatus as described in Fig. 1 will hold about 400 ml of ice on the condensing surface.

For operation, the condenser cone is filled with a freezing mixture of dry ice and ethyl cellosolve. The drying flasks are then filled to about 25 per cent. of their capacity with the solution to be dried and are placed in a dry ice freezing mixture. In order to obtain an even layer of material on the walls, the flask is held at an angle and rotated until all the material has frozen solid. When all the flasks are prepared, they are connected to the condenser and the assembly is evacuated. It is convenient to stopper unused openings of the condenser with sealed-off standard tapers which may also be used for drying small samples of material. The temperature inside the flasks depends upon the rate of evaporation, and under the

described conditions is well below freezing until all the water has been removed. The rate of evaporation may be increased by blowing a current of air over the flasks or immersing them in cold water. Materials

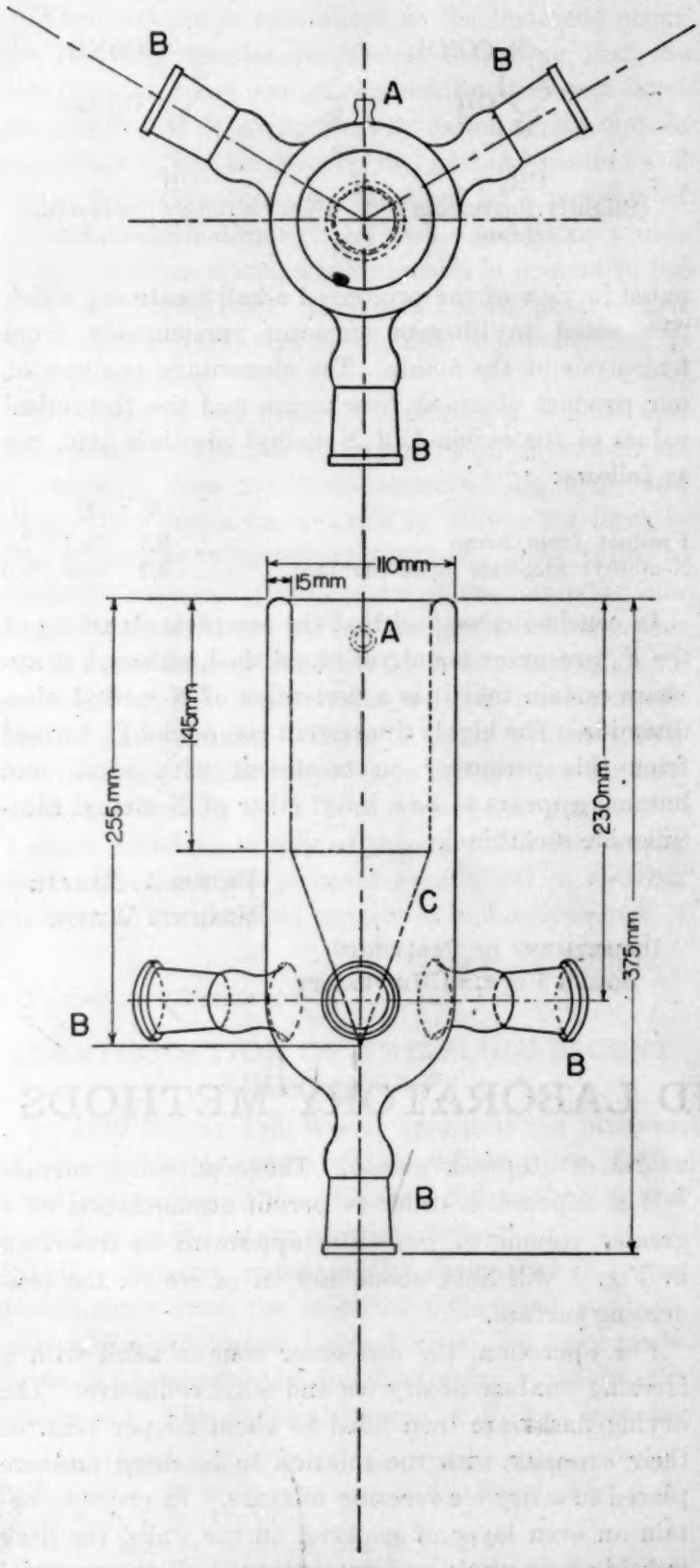

FIG. 1. Diagram of lyophil apparatus showing side and cross section views.

being dried from very dilute solutions have a tendency to be carried out of the flask with the current of water vapor; this may be prevented without causing any appreciable decrease in evaporation by placing a gauze screen over the opening of the flask.

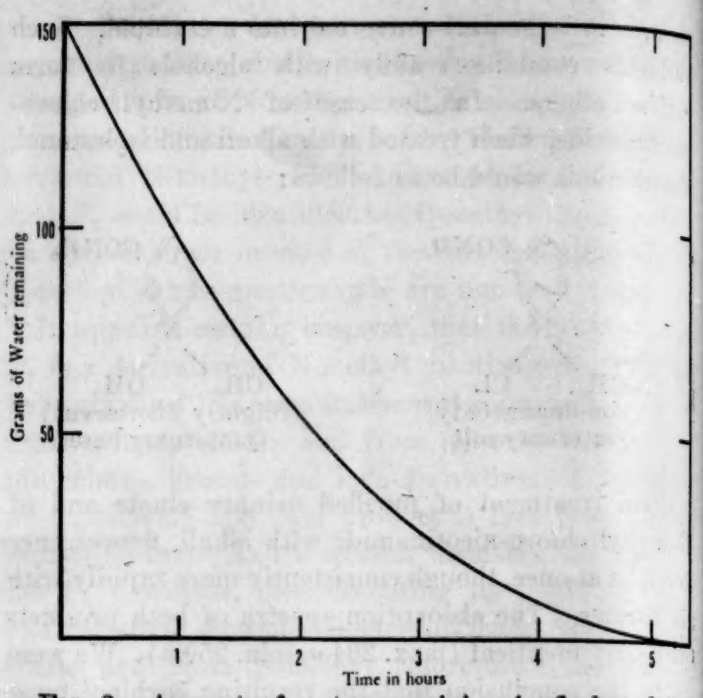

FIG. 2. Amount of water remaining in flasks, plotted against time.

Fig. 2 shows the amount of water remaining as a function of time for 150 gms of distilled water distributed equally among three 200 ml flasks. Complete dryness was achieved in about five hours. The decrease in rate at the end is mainly due to decrease in surface of the subliming ice. Water is evaporated from protein solutions at a comparable rate, depending to some extent on the hygroscopic nature of the material.

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BOOKS RECEIVED

BOWERMAN, MARY L. *The Flowering Plants and Ferns of Mount Diablo, California. Their Distribution and Association into Plant Communities.* Illustrated. Pp. xi + 290. The Gillick Press. $3.75.

CARLISLE, NORMAN V. and FRANK B. LATHAM. *Miracles Ahead. Better Living in the Postwar World.* Pp. xi + 288. Macmillan. $2.75.

FEJOS, PAUL. *Archeological Explorations in the Cordillera Vilcabamba, Southeastern Peru.* Illustrated. Pp. 75. Viking Fund. $3.50.

FENTON, ALFRED and S. W. CLARK. *The Use of Sulphur in the Control of Truck Crop and Cane Fruit Insects and Diseases.* Pp. 85. Texas Gulf Sulphur Company.

GAMOW, G. *Mr. Tompkins Explores the Atom.* Illustrated. Pp. 97. The Macmillan Company. $2.00.

GLASSER, OTTO, EDITH H. QUIMBY, LAURISTON S. TAYLOR and J. L. WEATHERWAX. *Physical Foundations of Radiology.* Illustrated. Pp. x + 426. Paul B. Hoeber, Inc. $5.00.

LINDER, FORREST E. and ROBERT D. GROVE. *Vital Statistics Rates in the United States, 1900–1940.* Pp. vii + 1051. U. S. Government Printing Office. $1.75.

LOBECK, A. K. and WENTWORTH J. TELLINGTON. *Military Maps and Air Photographs.* Illustrated. Pp. x + 256. McGraw-Hill Book Company. $3.50.

NEWMAN, STANLEY. *Yokuts Language of California.* Pp. 247. Viking Fund. $2.50.